

T2; and N stage was: 25 Nx, 65 N0, 26 N1, 1 N3. Mastectomy was performed in 17 and wide local excision in 100. Axillary dissection was done in 67 and sentinel node dissection in 33 with a median number of 13 (1-24) lymph nodes excised. 52 received chemotherapy and 72 endocrine therapy. All received radiotherapy (1 neo- and 116 adjuvant) with 67 breast/chest wall alone and 40 breast/chest wall and regional nodal irradiation. The median time to onset of LE from the completion of radiotherapy was 0.5 y (0.1 to 7.8). LEs included: 38 truncal and/or breast pain; 24 arm lymphedema; 16 breast inflammation; 16 breast lymphedema; 14 neck, truncal, breast fibrosis; 9 tissue ulcer/necrosis; 2 brachial plexopathy 2; and 11 other. Following LE consultation, 90 received pharmacologic (18 anti-inflammatory, 60 anti-oxidant, 12 pentoxifylline or 4 other) and/or non-pharmacologic management (33 self-lymphatic massage). Transient mild toxicities were observed in 8 (9%) (4 GI, 2 MSK, 2 pre-syncope). No major toxicities from LE treatment occurred. Moderate to significant improvement was observed in 78 (87%) with 12 patients demonstrating no improvement.

Conclusions: Following completion of therapy, acute toxicities may persist or late toxicities arise. For women with these toxicities, current interventions appear to have a meaningful impact upon LEs with minimal side effects. Recognition of the potential to manage persistent acute effects and LEs is important and needs to be better incorporated within breast cancer survivorship to best improve aftercare.

OC-0268

A Dutch nationwide survivorship care programme for (non-) Hodgkin lymphoma survivors

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Purpose/Objective: Survivors of Hodgkin lymphoma (HL) and subgroups of non-Hodgkin lymphoma (NHL) are at increased risk of various late adverse effects of radiotherapy and chemotherapy, leading to substantial excess morbidity and mortality. The need for long-term follow-up is increasingly recognized. Long-term follow-up care programmes have been established for childhood cancer survivors, but not yet for (N)HL survivors. Therefore, the Dutch BETER consortium (Better care after Hodgkin lymphoma: Evaluation of long-term Treatment Effects and screening Recommendations) has developed a nationwide infrastructure for survivorship care clinics for survivors of HL and subgroups of non-Hodgkin lymphoma (diffuse large B-cell lymphoma). The consortium aims to: 1) establish evidence-based follow-up guidelines for (N)HL survivors; 2) identify and trace survivors eligible for follow-up care; 3) educate survivors about possible late adverse effects of treatment; and 4) provide risk-based care and advice regarding prevention.

Materials and Methods: Follow-up guidelines were developed according to international standards. The guideline development group consisted of clinicians, methodological experts and patient representatives. We developed guidelines for second malignancies, cardiovascular disease, thyroid disease and osteoporosis after premature menopause. Recommendations are given for fertility care and family planning, therapy for neck muscle weakness, and infection prophylaxis for functional asplenia.

Results: We are currently identifying and tracing a cohort of approximately 8,500 HL survivors and 3,000 NHL survivors in 22 hospitals throughout the Netherlands, including all radiotherapy centres. Eligible patients for follow-up care survived for ≥5 years and were treated at ages 15-70 years from 1970 onwards. Survivors are identified through the Netherlands Cancer Registry, the nationwide pathology registry and hospital-based registries. Tracing of current addresses of survivors is done through the nationwide Netherlands Personal Records Database. For all survivors, treatment data are collected from medical records to provide risk-based screening recommendations. The website www.beternahodgkin.nl was developed to inform and educate survivors about late effects. Currently, a survivorship care plan is being developed. A nationwide database, including screening and adverse events data, is being developed to evaluate the follow-up guidelines for diagnostic value and efficacy.

Conclusions: We expect that the BETER project will improve healthy life expectancy and quality of life for (N)HL survivors. Evaluation of follow-up care will lead to improved knowledge regarding the diagnostic value and efficacy of the

proposed screening methods, contributing to more evidence-based follow-up programmes.

Proffered Papers: Brachytherapy 6: Physics - Dosimetry

OC-0269

Monte Carlo for HDR reference dosimetry

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Purpose/Objective: This work presents a Monte Carlo method for calculating the factors required to perform reference dosimetry in a water phantom for two different designs of ¹⁹²Ir Brachytherapy source used in the UK. The UK code of practice is an air-kerma based code however one sometimes wishes to perform reference dosimetry in a water phantom. We present a Monte Carlo calculation of the factors required to perform such measurements with an air-kerma calibration code. We present results with a thimble chamber calibrated at 10 cm with measurements at 2 cm in a water phantom.

Materials and Methods: The Geant 4 framework (Agnostelli et al.) was used to produce a simulation of an ¹⁹²Ir HDR Nucletron v2 microselectron source and a Varian Varisource. In the simulation the type of source and the position of the source relative to the chamber are definable at run-time. The source position is also a run-time definable quantity and so line sources can be created as a superposition of different source positions. The radioactive decay libraries in Geant 4 were used to simulate the decay chain. A single calibration factor k_{ch} can be determined from a series of four simulations as shown in (Ma and Nahum, 1993), where $D_w = MN_k k_{ch}$, D_w is the dose to water, M is the measured value and N_k the calibration factor. Alternatively k_{ch} can be calculated as the product of a series of factors (Reynaert et al. 1998). In this case k_{ch} is the product of stem and perturbation factors as well as a gradient correction, a correction for electron contamination due to high energy electrons from outside of the chamber and an angular response factor.

Results: There was very little difference between the energy fluence spectra between the sources. The spectrum of the Nucletron source is slightly harder in air although this is not seen in water. Many of our factors can be broadly compared with those in Reynaert *et al.* for verification. At a distance of 2 cm we found the gradient factor to be 1.11 for the Nucletron source, Reynaert et al. found this value to be 1.077 at 2.5 cm and 1.36 and 1 cm. The fraction of dose deposited in the sensitive volume due to electrons from outside of the chamber is 1.5% at 2 cm in this study and 1.4% at 2.5 cm in Reynaert et al. The ratio $(\mu_{en}/\rho)_{w/air}$ evaluated in water at cm is 1.100 for both Nucletron and Varian sources. For both sources this value is 1.109 at 2 cm in air. The product of the perturbation factor and the stem factor is 1.019, with the Varian source this was increased slightly to 1.028.

Conclusions: Monte Carlo provides a method for performing reference dosimetry for tasks such as audits using non-standard reference conditions. This can be done either by calculating factors required to calculate dose from an air kerma calibration or by direct Monte Carlo calculation of N_k from the dose deposited in the chamber. Having produced results broadly in agreement with previous work we are conducting experiments to verify our simulation more accurately.

OC-0270

Study of air density correction for new PTW SourceCheck 4Pi ionization chambers for low energy brachytherapy sources

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Purpose/Objective: To study the behavior of the new SourceCheck 4Pi ionization chamber with the air density for low energy brachytherapy sources of I-125.

Materials and Methods: Three PTW SourceCheck 4Pi chambers TW33005 were used with one electrometer PTW Unidos. As source, a I-125 selectSeed seed, manufactured by Isotron with an nominal air-kerma strength value of $S_K = 0.610$ cGy cm²/h was used. Barometer-thermometer-hygrometer PCE_THB 40 was used inside a home-made pressurized chamber controlled by a vacuum pump.

The direct measurements of the source used in this study must be corrected, according to our previous study of the preceding model of the SourceCheck chamber, with the following equation [1]:

$$M_{corr} = g_0(\rho) g_1(\rho) M_{raw}, \quad (1)$$

where there are two correction factors that depend on the air density.

The first one is:

$$g_0(\rho) = \left(\frac{\rho}{\rho_0} \right)^{-1} = \frac{(273.2 + T) P_0}{(273.2 + T_0) P},$$

that is actually the usual density correction factor, but explicitly written as a function of the air density inside the chamber, ρ , and the density of that air in normal conditions ($P_0 = 1013.25$ hPa, $T = 293.15$ K), ρ_0 .

The second factor is an additional one that shows up as consequence of the combination of two facts: On one hand the range of the secondary electrons produced by the I-125 is of the order of the dimensions of the active volume, and therefore, the Bragg-Gray theory does not hold; and on the other hand, the chamber materials influence the measurement. As shown in [1]:

$$g_1(\rho) = \left[A \left(\frac{\rho}{\rho_0} - 1 \right) + 1 \right]^{-1}. \quad (2)$$

Results: In the Figure, the results of the measurements for the I-125 made in the pressurized chamber are shown for different densities once they have been normalized and corrected by the pressure-temperature usual factor. The fits of Eq. (2) to these experimental data are also shown. The most relevant results are, firstly, the linear behavior of this dependence, and secondly, the coincidence, within the uncertainties, of the three chambers as far as their air density dependence is concerned. All uncertainties are associated to a coverage factor $k=2$.

Figure also shows the air density dependence as described for the HDR1000 Plus chamber [2] fitted by means of the equation (2), instead of use the potential model of Griffin et al. [2]. The air density dependence for the chambers SourceCheck 4Pi and HDR1000 Plus follows the same trend, that is, they have the same direction, being nevertheless somehow smaller for the former.